



U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: PRECISION APPROACH PATH
INDICATOR (PAPI) SYSTEM

Date: DRAFT
Initiated by: AAS-100

AC No: 150/5345-28E
Change:

1. **PURPOSE.** This Advisory Circular (AC) contains our requirements for Precision Approach Path Indicator (PAPI) systems.
2. **CANCELLATION.** AC 150/5345-28D is cancelled.
3. **APPLICATION.** We recommend these requirements for all applications involving airport development. The requirements in this AC are acceptable to comply with Federal Aviation Regulation Part 152 for projects funded under the Airport Improvement Program, or with Federal Aviation Recommendation Part 139 when required. When alternate means of meeting the PAPI requirements are proposed, it must be demonstrated that equivalent levels of performance, safety, and for federally funded projects, equivalent cost effectiveness, are achieved.
4. **METRIC UNITS.** To promote a transition to metric units, this AC uses both the English and metric systems. The metric conversions may not be exact equivalents. English units will govern until there is an official changeover to the metric system.

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FEDERAL AVIATION ADMINISTRATION
REQUIREMENTS FOR
PRECISION APPROACH PATH INDICATOR (PAPI) SYSTEMS

1. AC SCOPE

This AC contains the equipment requirements for PAPI systems.

1.1 PAPI Equipment Classifications

- a. Type.
 - (1) L-880 – System consisting of 4 light units.
 - (2) L-881 – System consisting of 2 light units.
- b. Style.
 - (1) Style A – Voltage powered (multiple circuit) systems.
 - (2) Style B – Current powered (series lighting circuit) systems.
- c. Class.
 - (1) Class I – Systems that operate from -31 degrees Fahrenheit (F) (-35 degrees Centigrade (C) to 131 degrees F (55 degrees C).
 - (2) Class II – Systems that operate from -67 degrees F (-55 degrees C) to 131 degrees F (55 degrees C).
- d. Options.
 - (1) Lamp socket bypass device in paragraph 5.3.2.
 - (2) An isolation transformer consolidating harness for Style B systems in paragraph 4.5.3.1.

1.2 Applicable Documents

The following documents are referenced in this AC.

- a. **FAA ACs.**
 - AC 150/5345-1, *Approved Airport Equipment*
 - AC 150/5345-26, *FAA Specification for L-823 Plug and Receptacle, Cable Connectors*
 - AC 150/5345-47, *Isolation Transformers for Airport Lighting Systems*
 - AC 150/5345-49, *Specification L-854, Radio Control Equipment*
- b. **FAA Standards and Drawings.**
 - FAA-STD-019, *Lightning and Surge Protection, Grounding, Bonding and Shielding*

*Requirements for Facilities and Electronic Equipment*FAA Drawing C-6046, *Frangible Coupling, Type 1 and 1A, Details*

Electronic copies of FAA ACs may be obtained from:

Internet: <http://www.faa.gov/arp/150acs.cfm>

or by standard mail from:

Department of Transportation
General Services Paragraph M443.2
Washington, DC 20590

Electronic copies of FAA Standards may be obtained from:

Internet: <http://204.108.10.116/nasiHTML/FAAStandards/>

c. **Military Specifications and Standards.**

MIL-C-7989 *Covers, Light Transmitting, for Aeronautical Lights, General Specification for*

MIL-STD-810 *Environmental Test Methods and Engineering Guidelines*

MIL-STD-461 *Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment*

Copies of Military Standards may be obtained from:

Internet: <http://www.dodssp.daps.mil/> (fees for documents)

or compact discs (CDs) on website order form by standard mail from:

DAPS / DODSSP
BUILDING 4 / SECTION D
700 ROBBINS AVENUE
PHILADELPHIA PA 19111-5094

d. **Illuminating Engineering Society (IES) Transaction.**

LM-35 *IES Approved Method for Photometric Testing of Floodlights
Using Incandescent or Discharge Lamps*

Copies of IES standards may be obtained from:

Internet: <http://www.iesna.org/> (fees for documents)

or by standard mail from:

Illuminating Engineering Society
120 Wall Street
17th Floor
New York, New York 10002

e. **Society of Automotive Engineers (SAE).**

AS-25050 *Colors, Aeronautical Lights and Lighting Equipment, General Requirements
for*

Copies of SAE Standards are available from:

Internet: <http://www.sae.org>

or by standard mail at:

SAE World Headquarters
400 Commonwealth Drive
Warrendale, PA 15096-0001 USA

2. PAPI SYSTEM

A PAPI system consists of:

- a. Four identical light units, Type L-880, or two identical light units, Type L-881.
- b. A power and control unit (PCU) (for style A systems only).
- c. Aiming and calibration equipment (may be part of the light units).

3. PAPI ENVIRONMENTAL REQUIREMENTS

You must design the PAPI equipment for outdoor installation and continuous operation in the following environmental conditions:

3.1 Temperature

The PAPI equipment must operate in the following ambient temperatures:

- a. Class I systems – from -31 degrees F (-35 degrees C) to 131 degrees F (55 degrees C)
- b. Class II systems – from -67 degrees F (-55 degrees C) to 131 degrees F (55 degrees C)

3.2 Humidity

The PAPI equipment must operate in any relative humidity up to 100 percent.

3.3 Sand and Dust

The PAPI equipment must operate when exposed to windborne sand and dust particles.

3.4 Wind-blown Rain

The PAPI equipment must operate when exposed to wind-blown rain from any direction.

3.5 Wind

The PAPI equipment must operate when exposed to wind speeds up to 100 miles per hour (mph) (161 kilometers per hour (km/hr) from any direction.

3.6 Salt Spray

The PAPI equipment must operate when exposed to a salt laden atmosphere with relative humidity up to 100 percent.

3.7 Sunshine

The PAPI equipment must operate when exposed to solar radiation with ambient temperatures stated in paragraph 3.1, Temperature Requirement.

4 LIGHT UNITS

4.1 Photometric Requirements

- a. Each light unit must have at least two lamps.
- b. The light units must produce a beam of light split horizontally, with white light in the top sector and red light in the bottom.
- c. When you view the PAPI at 1000 feet (300 meters), the transition from red light to white light must be within 3 minutes of arc at the beam center and within 5 minutes of arc at the beam edges.
- d. A line drawn through center of the transition band at +10 degrees, 0 degrees, and -10 degrees must be straight within 3 minutes of arc.
- e. The transition band must be flat within 3 minutes of arc.
- f. You must ensure the light distribution and intensity for each light unit is per Figure 1.

g. The PAPI light colors must be aviation white and red and meet the requirements of SAE AS25050, *Colors, Aeronautical Lights and Lighting Equipment, General Requirements for*, paragraph 3.1, Aviation Colors.

h. Light transmitting covers must conform to the requirements of MIL-C-7989, *Covers, Light Transmitting, for Aeronautical Lights, General Specification for*, Paragraph 1.2, Classification, Class B.

i. You must use lamps with a minimum rated life of 1000 hours in this application.

j. The lamps must be at their full intensity 5 seconds maximum after a cold start.

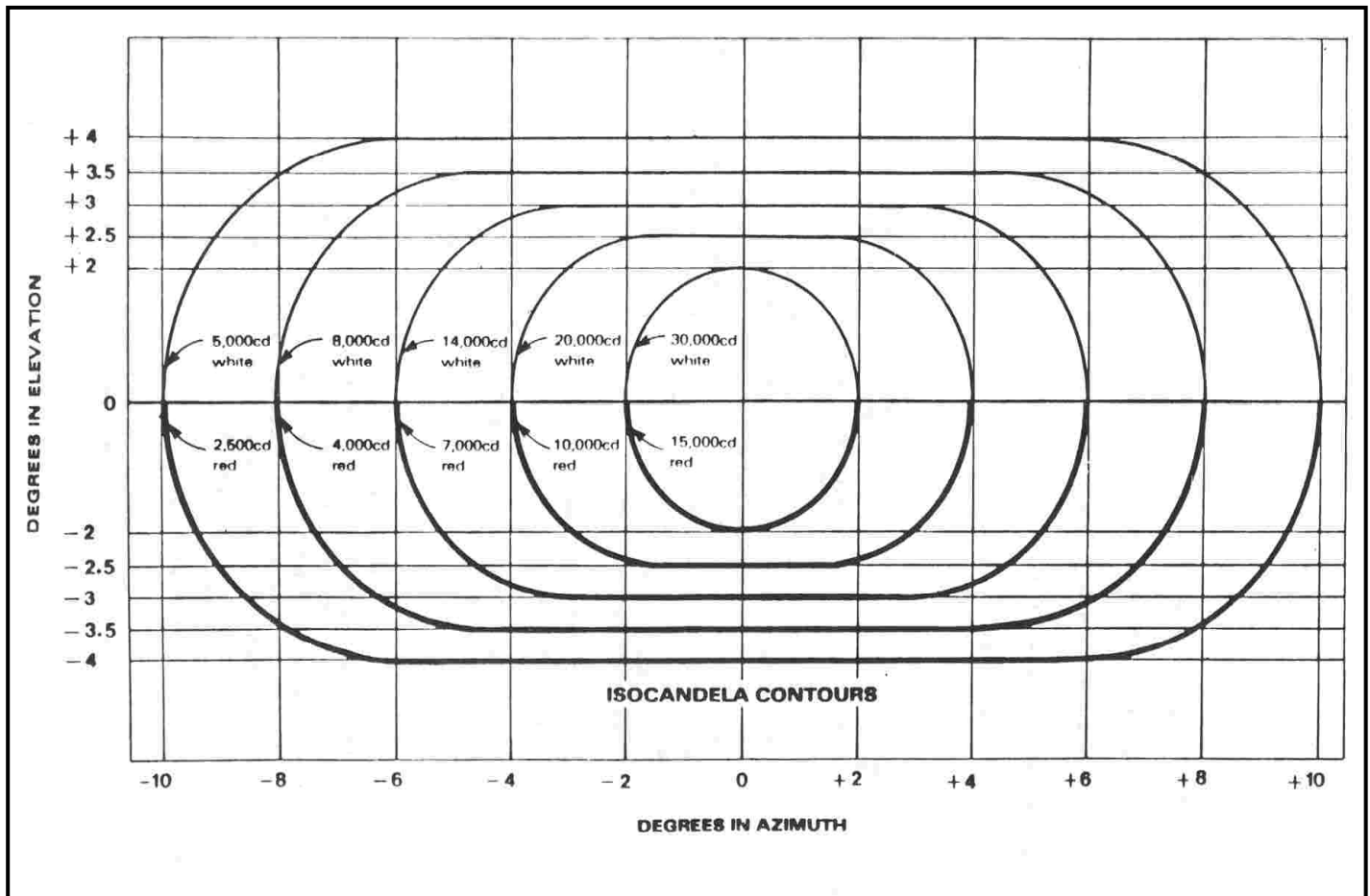


Figure 1. PAPI Light Distribution Requirements

4.2 Light Unit Construction

a. You must ensure light unit dynamic loading from wind, or static loading from snow or ice accumulation does not cause the light pattern to shift.

b. The weight of each light unit must not exceed 100 pounds (45 kilograms).

Note: If the PCU is part of the light unit, the weight limitation in 5.2(b) above will not apply.

c. A light unit may not be higher than 40 inches (1 meter) when installed at its minimum mounting height.

d. The light unit must use a protective overhang or other method to prevent rain or snow from accumulating on its lens surfaces.

4.3 Light Unit Mounting Provisions

4.3.1 Mounting Legs

a. You must use a minimum of three adjustable mounting legs for leveling the light unit when one side of the unit is installed up to 1 inch (25 millimeters) higher or lower than the opposite side.

b. At a minimum, the mounting legs must include:

- (1) a light housing mounting and level adjusting hardware;

Note: 2 inch electrical metallic tubing (EMT) must be furnished by the installer;

- (2) frangible couplings under FAA drawing C-6046;

- (3) and flanges for mounting the light unit on a concrete pad.

4.3.2 Adjusting Hardware

You must ensure the adjusting hardware is vibration resistant and prevents movement of the optical system.

4.3.3 Alternate Mounting Systems

You may propose an alternate light housing mounting system with equivalent rigidity, frangibility, and adjustability provided it meets all the requirements in this AC.

4.4 Light Unit Adjustments

4.4.1 Vertical Adjustment

All light units must use built-in adjustments for accurate vertical positioning of the light beam center at any elevation between 2 and 8 degrees.

Note: The center of the light beam is the transition band between red and white light.

4.4.2 Light Beam Aiming

a. You must furnish an aiming tool with the PAPI system that measures:

(1) The vertical angle of the light beam center from 2 to 8 degrees in graduated increments of 10 minutes of arc.

(2) The aiming tool must have a repeatable accuracy of ± 3 minutes of arc.

4.4.2.1 Alternate Light Beam Aiming

Light units may be factory calibrated to a fixed vertical angle specified by the purchaser.

a. The manufacturer must provide a procedure to check the calibration of the aiming system in the field with an accuracy of ± 3 minutes of arc.

4.4.3 Excessive Light Unit Tilt

a. You must ensure all lamps in the system are de-energized when the optical pattern of one light unit is lowered between 1/4 and 1/2 degree or raised between 1/2 and 1 degree with respect to the preset aiming angle.

b. You must ensure a delay between 10-30 seconds before de-energizing the light units to prevent intermittent activation caused by vibration or other movement.

c. The light unit tilt sensing must be fail-safe so any malfunction, including loss of input power, de-energizes the PAPI light units.

4.5 Light Unit Electrical Wiring

All wiring penetrating the PAPI enclosure must be connected with factory-molded plugs.

4.5.1 Lead Length

Power leads must be long enough to extend from the light unit, through a flexible conduit, and to a breakaway connector at ground level.

4.5.2 Strain Relief

You must use strain relief on any light unit power leads.

4.5.3 Plugs

a. Style B systems must use Class A, Style 1 or 6 plugs per AC 150/5345-26, *Specification for L-823, Plug and Receptacle, Cable Connectors*, to mate with the output lead of the isolation transformer.

b. Style A systems may use any plug with a capacity and electrical performance equivalent to an L-823 plug.

4.5.3.1 Alternate Plug System

You may furnish an alternate harness that accepts the output of several transformers and combines them into a single receptacle for use in the transformer housing. The receptacle must be located just below the light unit's frangible coupling and mate with a compatible plug from the light unit.

5. POWER AND CONTROL

5.1 Style A Systems

The PAPI power supply and control functions may be enclosed in a separate power and control unit (PCU) or inside a light box.

a. If the PCU is in a light box, the weight of the combined unit must not exceed 150 pounds (68 kilograms).

5.1.2 PCU Cabinet

a. The PCU cabinet must be an enclosure that meets the National Electrical Manufacturers Association (NEMA) Type 4 rating.

b. The PCU cabinet must contain all the power and control functions for a PAPI system.

c. You must be able to open the cabinet door 110 degrees minimum.

(1) The enclosure door must be equipped with a locking device to ensure it remains open during field maintenance.

d. The cabinet must be furnished with a padlock hasp to secure the cabinet door when necessary.

5.2. Style A Power

- a. The PAPI Style A system must operate from any standard utility single-phase alternating-current service voltage less than 600 volts.
- b. You must furnish a trip-free circuit breaker to allow de-energizing the PAPI system power.

5.2.2 Style A Voltage Regulation

The lamp socket voltage must be adjustable and regulated within 3 percent of its design value on the brightest step under the following conditions:

- a. the input line voltage deviates up to 10 percent above or below its nominal value;
- b. the individual light units are spaced between 10 feet (3 meters) and 30 feet (10 meters) apart;
- c. the Power Control Unit is located from 0 to 100 feet (30 meters) from the nearest light unit.

5.2.3 Style A Lamp Failure

When one or more lamps fail, it may not cause damage to either the power supply or the remaining lamps.

5.3 Style B Systems

- a. Style B systems must operate from a series lighting circuit with a current range of 2.8 to 6.6 amperes.
- b. You must ensure the lamps in Style B systems are compatible with an isolation transformer size per AC 150/5345-47, *Isolation Transformers for Airport Lighting Systems*.

Note: Components of the series lighting circuit (for example: L-828 regulator, isolation transformer) will not be supplied with the PAPI system.

5.3.1 Failure of Style B Lamp

Lamp failures may not cause damage to either the power supply or the remaining lamps.

5.3.2 Style B Lamp Shorting Device

You must optionally offer a lamp bypass device to short circuit the socket of a burned out lamp.

5.4 PAPI System Control

5.4.1 Photoelectric Intensity Control

You must equip the PAPI with a photoelectric type control that automatically switches the lamps between two operating modes:

- a. Day mode – 90 to 100 percent lamp intensity.
- b. When the system is first energized, and daylight is detected, the night mode must be selected between 2 to 3 seconds before switching to the day mode.
- c. You must ensure the photoelectric intensity control has a delay between 45 to 75 sec. before switching lamp intensity to prevent unintentional switching caused by transient light or shadows.

5.4.1.1 Day Mode Illumination Intensity

PAPI day mode must be selected when the illumination on a vertical surface facing north exceeds 50 to 60 foot-candles.

5.4.1.2 Night Mode Illumination Intensity

The night mode must be selected when the illumination on a vertical surface facing north decreases to 25 to 35 foot-candles.

5.4.1.3 Night Mode Intensity Settings

You must ensure there are two selectable night mode intensity settings, approximately 5 and 20 percent of full lamp intensity, to adapt the PAPI to airport ambient light levels.

5.4.1.4 Photoelectric Intensity Control Failure

You must ensure the PAPI automatically switches to night mode if the photoelectric control fails.

6. PAPI REMOTE CONTROL

You may optionally turn the PAPI on and off from a remote location.

a. Remote control may be by a hardwired cable or a radio frequency controller (specified in AC 150/5345-49, *Specification L854, Radio Control Equipment*).

7. PAPI EQUIPMENT TRANSIENT SUPPRESSION

7.1 Style A Surge and Transient Protection

a. You must determine the equipment susceptibility to power line surges and provide protection per FAA-STD-019d, *Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment, Section 3.5.4, Electronic Equipment Power Entrance*.

b. If the equipment uses 60 Hertz power to furnish operating voltages to solid state equipment, you must also ensure protection against transients per FAA-STD-19d, *Section 3.5.5, DC Power Supply Transient Suppression*.

NOTE: Series lighting circuits for Style B PAPI systems already have integral lightning protection on the regulator output. However, if any solid state components are used, paragraph 7.1(b) must apply.

8. EQUIPMENT GROUNDING

Conductive materials enclosing electrical conductors, equipment, or housings within the equipment must be connected to a common lug that allows connection to the system ground conductor.

9. EQUIPMENT FINISH

The exterior of all PAPI units must be aviation orange, color number 12197, or aviation yellow, color number 13538.

10. PAPI PARTS AND MATERIALS

- a. All PAPI system parts and materials must meet the environmental requirements in this AC.
- b. All parts and materials must be protected against corrosion.

(1) All fasteners and other hardware must be compatible with the material joined and may not cause galvanic corrosion.

c. PAPI system components may not be operated in excess of the component manufacturers recommended rating.

d. Plastic components exposed to sunlight must be oxidation and ultraviolet resistant.

11. PAPI MAINTENANCE

a. The PAPI system must be designed for ease of maintenance so field repairs and routine maintenance can be accomplished without special tools.

b. PAPI system components, excluding lamps, must have a mean-time-between-failure rate of at least six months.

c. If lamp defocusing occurs after lamp replacement, you must furnish any special tools and procedures required for refocusing.

d. If any special tools are required for other than routine maintenance and field repairs, you must furnish them.

12. WORKMANSHIP

The equipment must be fabricated under the highest quality commercial standards of workmanship.

13. PAPI INSTRUCTION BOOK

An instruction book containing the following information must be furnished with each system:

a. System schematic and wiring diagrams showing all components cross-indexed to the parts list;

b. Parts list with:

(1) part name,

(2) part rating,

(3) physical characteristics of the part,

(4) component manufacturer's name and part number.

c. Installation instructions, including procedures for aiming, calibration of the aiming system, focusing, and adjustment of the excessive tilt mechanism;

d. Maintenance instructions, including re-lamping procedure, theory of operation and trouble-shooting charts.

e. Operating instructions.

14. PAPI QUALIFICATION REQUIREMENTS

a. Procedures for qualification approval are in AC 150/5345-1, *Approved Airport Equipment*.

b. The following tests are required to demonstrate compliance with this AC. All tests may be performed on the PAPI power supply and a single light unit; any other units may be simulated by a resistive load.

14.1 Visual Examination

The equipment must be examined for compliance with the requirements in this AC for size, weight, materials, finish, and quality of workmanship.

14.2 High Temperature Test

- a. A high temperature test must be conducted per MIL-STD-810, method 501.4-1, Procedure II.

- (1) The equipment must be exposed to 131 degrees F (+55 degrees C) for 4 hours after temperature stabilization.

- (2) You must operate the PAPI during the temperature test.

- (3) Any deterioration in materials or system performance must be considered a test failure.

14.3 Low Temperature Test

- a. You must conduct a low temperature test per MIL-STD-810, Method 502.4-1, Procedure II.

- (1) For Class I systems, the equipment must be exposed to -31 degrees F (-35 degrees C) for 24 hours.

- (2) For Class II systems, the equipment must be exposed to -67 degrees F (-55 degrees C) for 24 hours.

- b. You must operate the equipment after temperature stabilization at the beginning and prior to the end of the test.

- c. Any deterioration in materials or performance must be considered a test failure.

14.4 Rain Test

- a. A wind-blown rain test must be conducted per MIL-STD-810, Method 506.4-1, Procedure I.

- b. The rain must be at a rate of 5.2 inches/hour (130 millimeters/hour) with an exposure time of 30 minutes per side.

- c. You must operate the equipment during the test.

- d. Any deterioration of system performance or excessive accumulation of water in equipment cabinets must be considered a test failure.

14.5 Salt-Fog Test

- a. A salt-fog test must be conducted per MIL-STD-810, Method 509.4-1, Procedure 1.

- b. The test duration must be 48 hours exposure and 48 hours drying.

- c. Any evidence of damage, rust, pitting, or corrosion (sacrificial coatings are excepted) must be considered a test failure.

14.6 Wind Loading

You must demonstrate by using either wind tunnel tests or static loading the system can withstand a 100 mph (161 km/hr.) wind load from any azimuth direction without displacing the optical pattern more than allowed in the rigidity test in paragraph 14.11.

14.7 Frangibility Test

You must demonstrate the frangibility of the PAPI mounting legs is the same as the 2-inch frangible coupling depicted in FAA drawing C-6046.

14.8 Transient Suppression Test

You must test the equipment immunity to transients per IEEE C62.45-2002 for a single phase power supply, Location A.

Note: The test waveforms to be applied to the equipment are described in FAA-STD-019d, Sections 3.5.4 and 3.5.5.

14.9 Photometric Tests

- a. You must conduct a photometric test for the color, intensity, and beam pattern requirements of paragraph 4 in this AC.
- b. All lamps used for photometric testing must be randomly selected from a production lot.
- c. You must perform the photometric requirements in paragraph 4 for one set of lamps.
- d. To demonstrate repeatability, you must check the intensity along the horizontal and vertical axes for two additional sets of lamps.
- e. If any refocusing is required after lamp replacement, it must be accomplished using your FAA approved procedure to demonstrate the required photometrics are reproduced.
- f. Before testing, you must ensure any test equipment is calibrated.
- g. You must ensure all measurements are taken at a distance that allows full focusing of the beam.

14.10 Lens Certification

You must furnish a certificate of compliance from the lens manufacturer stating the light unit lenses meet:

- a. The requirements in MIL-C-7989, *Covers, Light Transmitting, for Aeronautical Lights, General Specification for*.
- b. The color requirements in AS-25050, *Colors, Aeronautical Lights and Lighting Equipment, General Requirements for*.

14.11 Light Unit Rigidity Test

This test applies a static load equivalent to the maximum light unit design wind loading and determines if there is any movement of the light pattern.

- a. Before applying the static load, the light unit must be set up and the light pattern displayed on a vertical surface 20 feet (6 meters) in front of the light unit.
- b. The top, bottom, and the sides of the light unit beam pattern must be marked on the vertical surface in paragraph 13.10(a).
- c. A uniformly distributed sand load or other suitable material of 15 pounds per square foot (73 kilograms per square meter) must be applied over the entire top surface of the light unit.

Note: You may use a framework or other method to ensure the sand used to load the light unit does not spill over its sides.

d. The load must be applied by allowing the sand pour down on the center top surface of the light unit.

e. You must leave the sand load in place for 5 hours.

f. After 5 hours has elapsed, the light housing beam pattern must be checked for any movement from the original marks drawn in paragraph 13.10(b).

(1) The light unit beam pattern must be within $\pm 1/4$ inch (6 millimeters) of the original markings.

g. Remove the sand load.

h. You must recheck the beam pattern against the markings in paragraph 13.10(b), and mark any movement.

(1). The light unit beam pattern must be within $\pm 1/4$ inch (6 millimeters) of the original markings.

14.12 Aiming Device Test

a. You must test the aiming device, using your own procedure (approved prior to testing by the FAA), to demonstrate when the light unit is moved by the adjustment mechanism, the measuring device indicates the change with an accuracy of ± 3 minutes of arc.

b. The measuring device must be checked at one-degree intervals from 2 to 8 degrees.

14.13 Operational Test

a. You must conduct a PAPI system operational test, using your own test procedure (approved prior to testing by the FAA), to demonstrate compliance with all operating requirements.

b. Your procedure must test:

(1) the excessive tilt mechanism;

(2) the power supply performance (current, voltage while at full brightness);

(3) the photoelectric controller;

(4) operation with one lamp out per light unit;

(5) if the failure of a lamp produces transients or over-voltage conditions that damage the remaining lamps.

15. PRODUCTION TESTS

a. You must submit a test procedure for FAA approval to verify the light output and aiming device accuracy for each production unit.

b. After FAA approval, the test procedure must be used for all production units.

c. You must also perform the visual examination in paragraph 14.1 and the operational test in paragraph 14.13 for each production system.